

Speaking Films.

By PROF. A. O. RANKINE.

THE publicity recently given (*Times*, September 24 and 28) to reports of the successful synchronisation of speech and action in cinematography makes the present an appropriate time for describing the production and use of photographic films bearing sound-records which are reproducible. For the novelty of the recent inventions does not lie in the speaking films themselves, but in their combination with picture films so as to constitute the so-called "talking pictures." It was about the year 1900 that Ernst Walter Rühmer made the first speaking film. The process is described in his book on "Wireless Telephony," translated into English by J. Erskine Murray in 1908. Rühmer's invention was the natural outcome of his work on photo-telephony, the principles of which are treated in the same work. In photo-telephony there are imposed upon a projected beam of light fluctuations of intensity which correspond to the sound-vibrations associated with speech; for purposes of reproduction the light is allowed to fall upon a selenium¹ cell, which, by its well-known photo-electric property, controls the current in a telephonic circuit. It was a simple modification to carry out the process in two distinct stages, viz., (1) to photograph the fluctuations of the light upon a moving film, and (2) to actuate the selenium cell at leisure by interposing between it and a source of light, the developed film moving at the same speed as before. For this device Rühmer chose the descriptive but ugly name "photographophone," and printed reproductions of some of the films obtained by him appear in that chapter of his book which bears this name.

Rühmer's method of obtaining the fluctuations of light corresponding to speech was to superimpose upon the current in an electric arc variations due to a microphone actuated by the voice. This method has been used by several later investigators, including H. Thirring (*Phys. Zeit.*, p. 67, 1920), who has also devised a particularly sensitive form of selenium cell. The chief difficulty in connection therewith appears to be that of keeping the arc in a sufficiently sensitive condition. In an entirely different method, due to the author, described in *NATURE* for February 5, 1920 (vol. 104, p. 604), under the title "Telephoning by Light,"² this difficulty does not present itself, and a fluctuating beam of light with the necessary characteristics is obtained with ease. Its application to the pro-

duction of speaking films has already been indicated (*Proc. Phys. Soc.*, vol 32, p. 78, 1920), but many new records have been obtained since the date of that publication.

The mode of recording adopted, which differs in no essential respect from Rühmer's, is to allow the fluctuating beam of light emerging from the photophone transmitter to fall upon a condensing lens, L_1 (Fig. 1), so that an image of the original source of light is formed at S. A narrow, horizontal slit thus illuminated at S serves as a secondary source, and the lens L_2 brings an image of it to a focus upon a continuously moving photographic film suitably enclosed. A slightly different arrangement, which is superior optically, is to place a larger slit close to, and extending over the full aperture of, the lens L_1 , and to obtain on the film a suitably diminished image of the slit by giving the lens L_2 the appropriate focal length. By providing in addition that the focal length of L_1 is equal to the distance L_1L_2 , the image of the original source, usually quite small, coincides with L_2 , of which the central region only is thus used, and aberration is much reduced. It will be seen that the moving film is exposed to

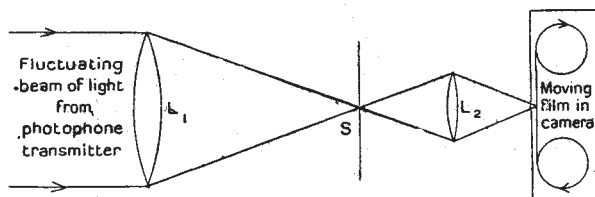


FIG. 1.

a narrow bar of light, perpendicular to the direction of motion, of which the intensity is varying in accordance with those sounds which have actuated the photophone beam. The result is that the film, when developed, shows a band varying in opacity as the length is traversed, and looking very much like a discontinuous spectrum. Two examples (reduced by one-fourth) are shown in Fig. 2—the records of the words "beet" and "this" respectively. They have been chosen because they are short, staccato words capable of being reproduced in the space available. The beginning of each word is at the top, and the speed of the film was about 1.3 metres per second. The amount of detail shown in these records depends, of course, upon the relation between the width of the slit image on the film and the film velocity. For those shown the slit image was about 0.2 mm. wide, so that frequencies of several thousand per second, if present, should be visually detectable.

The procedure for reproducing the sounds from the films is very simple. All that is needed is to

¹ Selenium is not the only substance suitable for this purpose. Other photo-electric cells have been constructed during recent years, notably the "thalofide cell" of T. W. Case and the "antimonite cell" due to W. S. Grippenberg. The sensitive substances here involved are sulphides of thallium and antimony respectively. The relative merits of such cells are open to question, and require careful experimental investigation; but they do not affect at all the principles of sound-reproduction from photographic films as described in this article.

² The article here referred to should be read in conjunction with the present one.

focus the light from a narrow source upon the film, and to allow the light which penetrates the

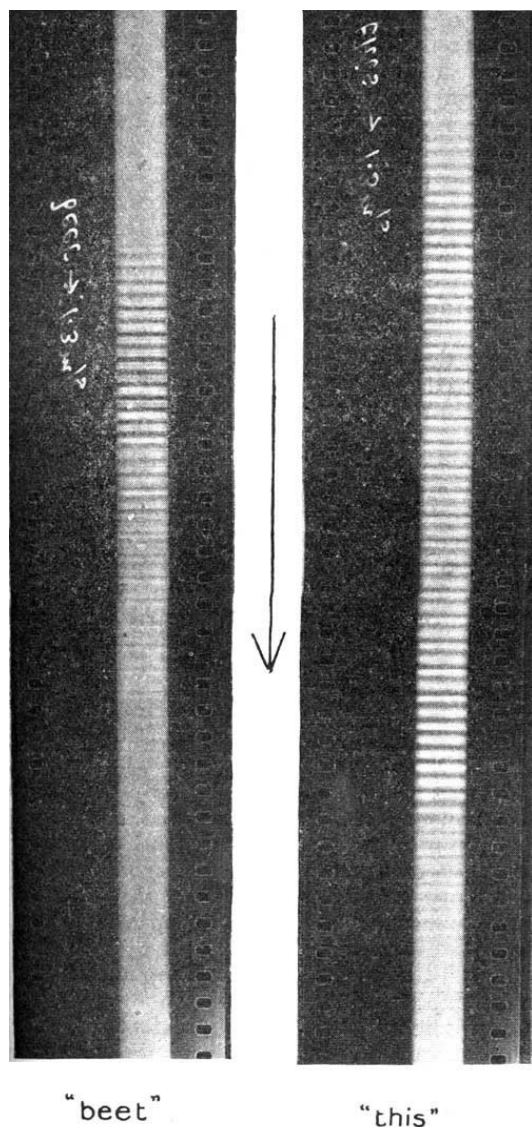


FIG. 2.

film to fall upon a selenium cell connected with a battery and telephone receiver. For example, the arrangement shown in Fig. 3 works satisfactorily. Here the slit S is illuminated by the condensed light from the arc, and its image is formed on the moving film at F. The light reaching the selenium cell, upon which, if necessary, it can be concentrated by an additional lens, is caused to fluctuate as the film moves, so that the corresponding sounds are heard in the telephone. It is usually necessary to amplify the feeble telephone currents by means of one or more thermionic valves. Mr. Bergland, the Swedish inventor whose recent kinematograph work

elicited this article, has apparently been able to attain augmentation sufficient to actuate effectively loud-speaking telephones so as to be audible throughout a room; but the number of valves used in cascade has not been announced.

There are certain somewhat remarkable features in connection with the sound reproduction from films such as those illustrated. These, although already enumerated (*loc. cit.*), are worth emphasising. Strictly, in order that the sound-vibrations reproduced may correspond exactly to those which originally controlled the beam of light and gave the photographic record, the speed of the film should be the same during recording as during reproducing; but the ear and brain are apparently capable of recognising a word even though the frequencies associated with its utterance have been altered in constant proportion to a considerable degree. This applies more to some words than to others, but, generally speaking, precise equality of film speeds in recording and reproducing is not necessary, nor does there prove to be any need to take particular care to secure the correct photographic density; the articulation of the reproduced sounds is wonderfully good without this elaboration. Most remarkable of all, however, is the small effect arising from widening the slit image used during reproduction. It has been found that this image may be made several times wider than when recording without marked deterioration of the reproduced words. All this points to the fact that effective listening demands only the existence of the chief features of the complicated vibrations constituting speech sounds. The practical effect is that in gramophones generally the speed used need not be so large as to record all the finer details existing in the vibrations, and in the case of the particular optical gramophone under consideration, a film speed much less than that indicated above would suffice. Experiment proves this to be true, and successful films have been made, as was anticipated, with speeds of about 40 cm. per second (the approximate rate in the kinematograph as ordinarily used) and a slit image 0.2 mm. wide. The degree of success in reproduction may be judged from the fact that single words, isolated from all context, are nearly always recognised at once, in spite of the severe test which such an arrangement obviously imposes.

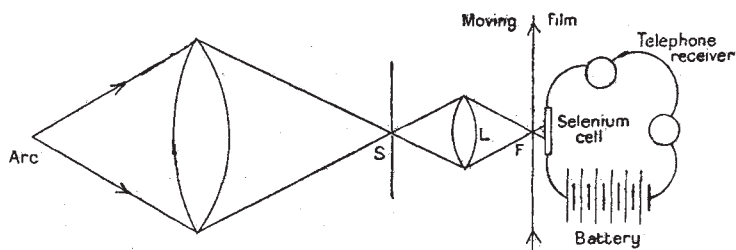


FIG. 3.

In passing from the consideration of speaking films alone to their synchronous combination with kinematograph pictures, we pass from facts well

established scientifically to information at present only obtainable in newspaper reports. Emphasis need not be laid on the obvious advantages of a film sound-record over an ordinary mechanically produced gramophone record. Combinations of picture films and ordinary gramophones have been frequently tried without success sufficient to ensure their survival in practice. The difficulty, of course, mainly arises from the impossibility of *preserving* synchronism between a gramophone record and a film the length of which is gradually but inevitably shortened by the repairing of frequent breakages. With the sound-record also upon a film, the appropriate adjustment can always be made, especially in the ideal case where a single film bears both picture- and sound-records, side by side, under which conditions it becomes automatic. The arrangement of two separate films, run both in recording and reproducing on the same shaft, has, according to the *Times* report, been adopted by Mr. Bergl nd; Mr. Grindell Matthews, on the other hand, announces that he has been able, in spite of the small space available, to secure the advantages of a single film, a newspaper reproduction of which is given. In neither case are the reported details complete enough to indicate the actual mechanism employed. One point of somewhat curious interest

seems, however, to be fairly definitely established. An examination of the printed reproduction of Mr. Grindell Matthews's film shows that the sound-record is of what may be called the *ordinary* type — i.e. it consists of the trace of *transverse* movements of a spot of light on a moving film, so familiar in oscillograph and other wave-motion records. A talk which the author was fortunate enough to have recently with Prof. Arrhenius, who was present at the first demonstration of the new Swedish talking pictures, made it clear that Mr. Bergl nd also relies on this same plan. It is not easy to see how such transverse records lend themselves to effective sound-reproduction. On the face of it, they would appear to be distinctly inferior for this purpose to the records described and illustrated in this article, and details of the manner in which the selenium is actuated will be awaited with interest.

We have yet to learn also by what mechanism synchronisation has been effected. For, although the principle involved is very simple, and the general method of procedure is quite obvious, there have no doubt arisen in practice details which present serious difficulties. We may hope to hear before long what these are and how they have been surmounted.

The Oppau Explosion.

THE directors of the Badische Anilin- und Soda-fabrik state in the *Zeitschrift f r Angewandte Chemie* for October 4 that the explosion at the nitrogen fixation works at Oppau on September 21 took place in a store containing about 4500 tons of ammonium sulphate nitrate. They explain that, before the war, only sulphate of ammonia was made at Oppau; ammonium nitrate was manufactured during the war, and since then, mixtures of ammonium nitrate and potassium chloride, and more recently ammonium nitrate and sulphate for use as fertilisers. They definitely state that no ammonium nitrate was present in the works at Oppau at the time of the explosion, and go on to say that while the explosive nature of ammonium nitrate is well known, this feature can be completely eliminated by mixing it with potassium or sodium chlorides; the double salt, $2\text{NH}_4\text{NO}_3 \cdot (\text{NH}_4)_2\text{SO}_4$, had also been shown to be non-explosive when pure as well as when it is produced on the works scale. They proceed to quote evidence as to the non-explosive character of this salt from the fact that it gives no distension in the Trauzl block test, when exploded by means of a detonator containing 2 grams of mercury fulminate, and in substantiation of its innocuous character they adduce the fact that in factories producing it no accident has occurred for a number of years, when explosives have been applied to it for the purpose of breaking up blocks of the mixed salts which have set hard. They deny that

Oppau was completely destroyed, and say that the portion of the factory devoted to the production of ammonia from the air and of ammonium sulphate is comparatively uninjured, so that the manufacture could be started again, and they end with an assurance that the production of ammonia by high pressure as carried out by the Badische Anilin- und Sodafabrik has nothing whatever to do with the explosion.

It may be remarked in connection with this statement that no reference is made to experimental work on the explosive character of their product on a larger scale than by attempting to fire it by a No. 8 detonator in a Trauzl block. It is known, however, to explosive technologists that ammonium nitrate responds only feebly to such a detonator, but that it can be brought up to detonation by a suitably chosen initial impulse.

The *Times* of October 12 gives an account of some very remarkable evidence brought out at a sitting of the German Parliamentary Committee appointed by the Reichstag to inquire into the explosion. It appears from the evidence that the process was being worked intensively and without adequate chemical control, and it is stated that in the preparation of the ammonium sulphate nitrate the ammonium nitrate was not always dissolved, but passed on to the store as such. Evidence was also given as to the fact that blasting was resorted to for the purpose of breaking up the hardened mass, and in a further report, published in the